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Community Perspectives on Fuelwood Resources in East Africa

Enrichment and Extraction Along the Eastern Slopes of Mount Kenya

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Communities living near protected forests rely on these areas to supply fuelwood among other extractive resources. This research was conducted in Kiang'ondu sublocation, within the eastern buffer zone of Mount Kenya Forest Reserve, and it addresses 2 research questions. (1) What is the diversity of fuelwood resources that communities extract from the forest reserve and enrich in their home areas? (2) What are the perceptions of community residents about the opportunities for a sustainable fuelwood supply? Mixed participatory exercises revealed 32 fuelwood plants, native and nonnative, which are acquired from the forest reserve or from people's homes and farmlands. These plants differ by their other material uses, attributes as a fuelwood, and ease of propagation. Use practices and perceptions vary with distance from the reserve, but people are not fuelwood limited at either location. Adaptive resource management can build from a local understanding of fuelwood that enhances conservation practices toward a sustainable supply.

Keywords: *Community resource management; fuelwood; montane forest; participatory learning; East Africa.*

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Introduction

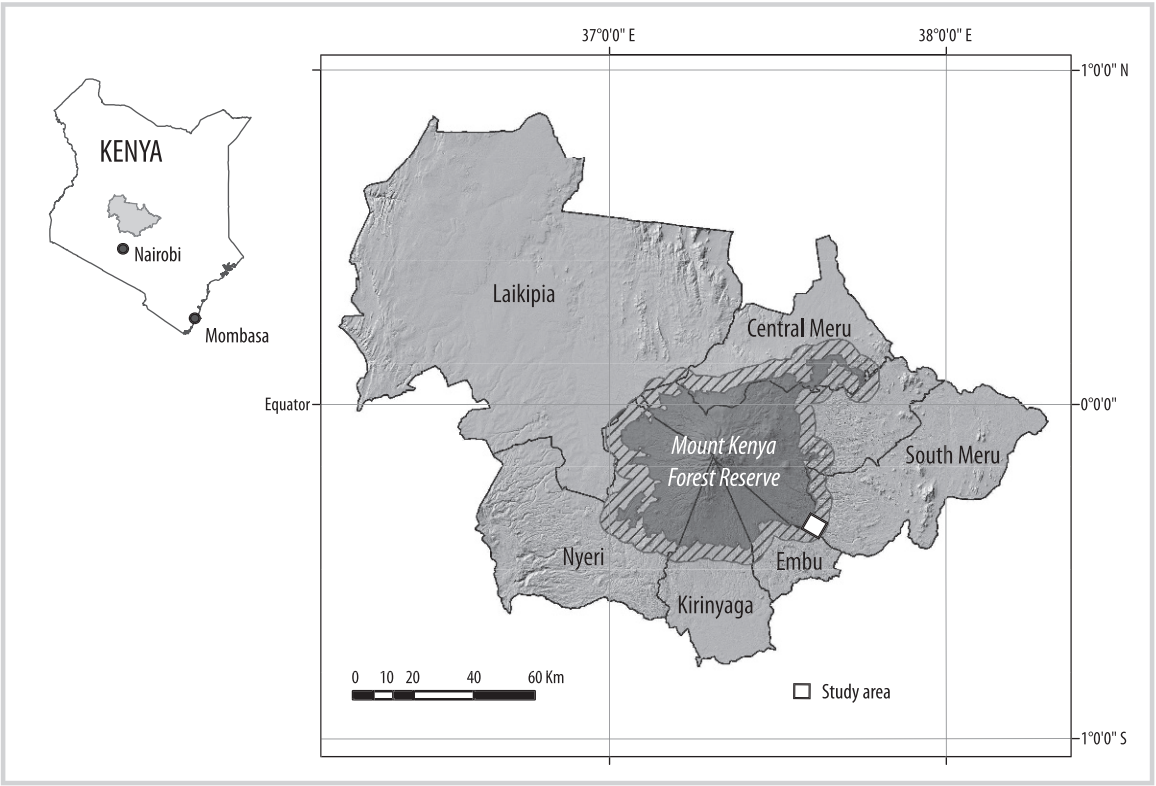
Extralocal political forces and local cultural adaptations complicate conservation development for energy resources, especially in mountain regions where human–resource relations can differ distinctly across environmentally complex landscapes (Rocheleau 2007). High population densities characteristic of productive montane zones can be a negative influence on resource sustainability, but cultural–political ecologists have also presented a number of compelling case studies demonstrating that population growth does not invariably lead to environmental degradation (Templeton and Scherr 1999). When accompanied by resource diversification, local populations can promote sound environmental management (Homewood 2005). Utilizing a cultural–political ecology viewpoint, this research looked at community opportunities to sustain an important energy resource, fuelwood, for local livelihoods in the montane forests of Mount Kenya. East African tropical montane forests comprise only 0.1% of the global total (Wasser and Lovett 1993), but they are the primary source of timber and non-timber resources, provide a critical source of freshwater, and support much of the region's biodiversity (Chapman and Chapman 1996; Küper et al 2004). The sustainability of fuelwood resources in mountain regions is an important conservation and development concern because of the potential conflict between extralocal forces that promote forest protection and local communities that rely on woody plants as their only source of energy.

Much research documents the ways in which humans deplete forest resources by various forms of ***extraction*** (eg cutting trees, pruning branches, collection of edible and medicinal plant parts; Cunningham 2001). Local resource extraction occurs as a livelihood strategy in response to communities' needs and the availability of those resources. In contrast, this research also considers the ways in which local communities ***enrich*** forest resources across a montane landscape (Martin et al 1999). To secure resources for future generations, international and national development priorities are shifting toward the restoration of highly modified or degraded landscapes to ensure resource sustainability. For example, The Green Belt Movement (GBM), formed in 1977 in Kenya, is a nongovernmental organization that received international recognition for the way in which it manages to bring local women's groups together to restore "lost nature" by planting trees, mostly near their homes and farms (Maathai 2006).

The purpose of our research project was to gain a better understanding of extraction and, more importantly, enrichment processes that contribute to the fuelwood needs of local communities living in a montane buffer zone near the Mount Kenya Forest Reserve. We employed a participatory learning approach and

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FIGURE 1 Map showing the location of the study area (box) in the Kiang'ondu sublocation of the South Meru administrative district. Kiang'ondu sublocation occurs within the 5 km buffer zone that surrounds Mount Kenya Forest Reserve. (Map by the authors)



qualitative methodologies (Slocum et al 1998) to investigate local activities and perceptions related to the use and conservation of fuelwood. The study addressed 2 research questions with people of Chuka ethnicity.

1. What is the diversity of fuelwood resources that communities extract from the forest reserve and conserve or plant in their home areas?
2. What are the perceptions of community residents about the opportunities for ensuring a sustainable supply of fuelwood?

The study supported an experiential learning process where women and men participants assessed the diversity of fuelwood resources and offered insights that contribute toward a more adaptive resource management approach (eg Colfer 2005).

Study area

Mount Kenya (00°10′S, 37°18′E; 5199 m), located in central Kenya (Figure 1), is 1 of only 2 snow-capped peaks in Africa and a vital rainfall catchment area (Gichuki 1999). The mountain's massif is of recent volcanic origin, contributing to soils of high fertility. Designated as a World Heritage Site in 1997, Mount Kenya supports the largest and most ecologically diverse forests in the country, which are also among the most threatened because of their commercially valuable timber resources and the large human population living in the land-scarce area around its boundary (Bussmann 1996). About 140,000 ha of indigenous montane forests occur between 1700–3500 m within the Mount Kenya Forest Reserve (Ndegwa 2005).

A 5 km buffer in the lower montane forest zone around Mount Kenya was designated before independence, where socioeconomic opportunities were made available to local communities (Figure 1). The study area, Kiang'ondu sublocation, is in the Meru South administrative district on the eastern slopes within this buffer. Environmental conditions support subsistence crops such as sweet potatoes, maize, beans, and potatoes, and the commercial production of coffee, tea, and other horticultural crops. Dense human settlements (~600 people/km) create a clear boundary between the rural agricultural landscape and closed forest (Ojany 1993; Ndegwa 2005). Chuka, Meru, Embu, and Kikuyu ethnic groups became mixed under colonial settlement programs around Mount Kenya, but after independence, the Chuka people gained land titles and now dominate the buffer zone in Kiang'ondu sublocation. The study compared 2 locations. Kariako locality is near the forest reserve, and Mukungugu locality is about 5 km further south along the outer buffer zone.

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Research methods

During a preliminary visit before research began in the study communities, we identified a male local community advocate and a respected male elder to serve as research assistants. We first took a familiarization tour from which the elder sketched a map of Kiang'ondu sublocation. While the study focused on 2 localities, Kariako and Mukungugu, the viewpoints of other residents were also gathered as we walked across the sublocation and during meetings held at the centrally located Kiang'ondu market center.

Diversity of fuelwood resources

A first important objective for the field research was to record the diversity of fuelwood resources used by local residents. We compiled a cumulative list of fuelwood trees during scheduled transect walks and through participatory observations in their home areas. We walked with women and men participants across the landscape where they reside, providing an opportunity to see and talk about fuelwood resources. On some afternoons, we obtained fuelwood with community members, thereby learning more about the particular plants used and their source locations. The study compares findings collected in Kariako and Mukungugu, where we spent approximately 3 and 2 weeks from June to August 2009, respectively. Plant vouchers of fuelwood plants were collected and confirmed at the East African Herbarium (EA), and copies were carried to the Willard-Sherman Turrell Herbarium at Miami University (MU), Oxford, OH, USA.

Opportunities for a sustainable fuelwood supply

The study employed participatory exercises (Slocum et al 1998) and semistructured interviews in order to rank species preferences and compile narratives on the opportunities for a sustainable fuelwood supply. A meeting day was scheduled at the Kiang'ondu market center, inviting residents from Kariako locality and Mukungugu locality who had participated in the transect walks and household surveys. Other residents also volunteered, providing local views for the Kiang'ondu sublocation. For all identified fuelwood plants, the participants were asked to describe other material uses, rendered environmental services, and their attributes as an energy resource. From this list, the residents selected 10 trees as most important, and then these trees were compared in a pair-wise ranking matrix by asking: Which tree between these 2 trees is preferred as a fuelwood resource? At the household level, family members were asked to show their fuelwood collection sites and share their practices by describing photos that illustrate the ways they manage fuelwood.

Results

Gaining a sense of place

The field map constructed by the village elder at Kiang'ondu sublocation shows a complex social–political structure for the study region (Figure 2). The Tungu River to the east, the Naka River to the west, Chuka University road to the south, and the Mount Kenya Forest reserve to the north form the boundaries of Kiang'ondu sublocation. The area is approximately 25 km^2 and is divided politically into subunits and localities, which correspond to the distribution of settlements as confined by the rugged mountain topography and places of community gathering like churches, schools, tea- and coffee-buying centers, and the central market (Figure 2).

A locality is a group of households dwelling in 1 area and overseen by 1 village elder selected by the residents. Localities, working through their village elders, can be very influential toward implementing new ideas in the sublocations. The field map identifies the geographic position of Kariako near the Mount Kenya forest reserve and Mukungugu about 5 km to the south, and it also shows the market center that served as the central meeting location for group discussions on fuelwood resources (Figure 2).

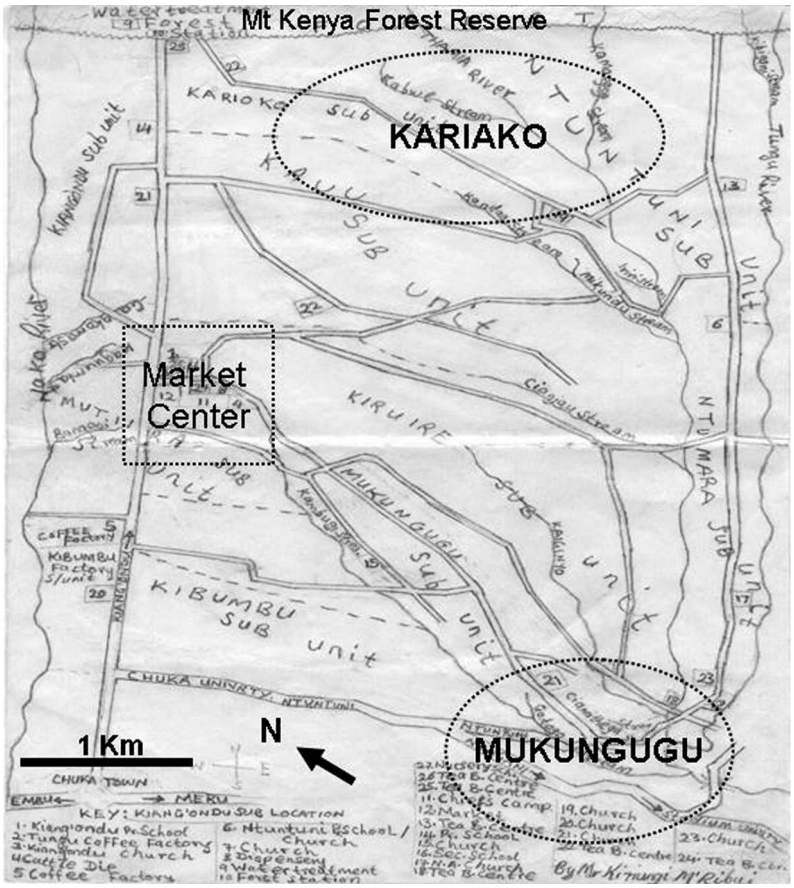
Diversity of fuelwood resources

We conducted 5 trips to fuelwood collection sites: 1 to Mount Kenya Forest Reserve with residents from Kariako; and 2 transect walks across homes and farmland at each locality. From the surveys and conversations at the homes, 32 fuelwood species were identified and collected in 30 genera and 17 families (Table 1). Most common plant families included Leguminosae (5 spp.), Euphorbiaceae (4 spp.), and Myrtaceae (3 spp.). Four species were shrubs, including *Cajanus cajan*, *Calliandra calothyrsus*, *Camellia sinesis*, and *Lantana camara*, and the rest of the 32 species were trees. Eleven species were nonnative, and 21 were native to the locality. According to the focus group participants, 4 native tree species are only found in the forest reserve, including *Landolphia buchananii*, *Bersama abyssinica*, *Rothmannia urcelliformis*, and *Syzygium guineense*. The majority (59%) of the tree species were reported planted around people's farmland and homes, including especially *Acacia mearnsii*, *Coffea arabica*, *Grevillea robusta*, *Macadamia integrifolia*, *Mangifera indica*, and *Persea americana*. These trees were favored because they provided other key resources in addition to being a source of fuel. All the 32 tree species identified had local (Chuka) names except *Calliandra calothyrsus*, which is a fodder species promoted by Kenya Agriculture Research Institute (KARI) in this area (Table 1).

Kariako and Mukungugu localities had almost the same number of fuelwood species on their properties, 19 and 22 species, respectively, but they did differ in their composition (Table 1). Out of 21 native tree species, 6

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FIGURE 2 Elder's map of the study area in Kiang'ondu sublocation. The map shows the 2 localities, Kariako near the forest reserve and Mukungugu near the edge of the 5 km buffer zone, and the centrally located market center where meetings were held.



trees occurred in both localities; 6 species were unique to Kariako, and 3 species were unique to Mukungugu. Out of 11 nonnative tree species, 6 were found in both Kariako and Mukungugu localities, and 4 trees were only reported in Mukungugu locality.

Occurrences of the 32 fuelwood species in the 2 localities were described according to whether trees were planted or grew naturally (Table 1). Respondents described planting as a process that involves obtaining seeds, germinating them in a tree nursery, caring for the young seedlings, transplanting them to their farmlands and the forest reserve, and nurturing seedlings as they grow. Those trees that germinate on their own and keep growing without human attention were referred to as "natural" trees. At Kariako, 12 tree species were planted, including native *Croton megalocarpus* and *Eriobotrya javanica*, and 12 occurred naturally. At Mukungugu, only 11 tree species naturally occurred on the farmland, including native *Senna didymobotrya*, *Croton macrostachyus*, and *Bridelia micrantha*, but 16 species were planted. Some participants said that Mukungugu residents hold larger farm sizes, providing more space for a variety of trees to be planted, either as woodlots or intercropped with other crops.

During 1 Mukungugu household interview, a participant said that because of the high demand for fuelwood, he would replace a naturally slow-growing tree species with a faster-maturing tree, such as *Grevillea robusta*, *Eucalyptus grandis*, and *Eucalyptus saligna*, in order to maximize opportunities for meeting fuelwood needs. *Eucalyptus grandis* and *Eucalyptus saligna* were found growing on people's farmland mostly as woodlots. The participants said that both trees, called "*Munyua mai*" (drinking water), take a lot of water from the topsoil when intercropped. In Mukungugu locality, residents said that they are encouraged to plant trees for fuelwood, while residents in Kariako locality conserve naturally established trees, not necessarily for fuelwood, but for their other material uses and environmental services. Some trees were indicated in both categories as planted and natural. Native *Albizia gummifera*, *Cajanus cajan*, *Markhamia lutea*, *Prunus africana*, and *Vitex keniensis* were reported planted on farmland, and nonnative *Lantana camara* and *Grevillea robusta* were planted along the road and property boundaries; also, due to their easy seed dispersal and quick germination, these woody plants are naturally established especially along forest or farmland edges.

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TABLE 1 List of fuelwood trees species confirmed during the field study. Plant vouchers [in square brackets] were deposited at the East African Herbarium (EA) and the Willard-Sherman Turrell Herbarium at Miami University (MU), Oxford, OH, USA. Nonnative tree species are shown with 1 asterisk (*), while native tree species reported growing in Mount Kenya Forest Reserve are shown with 2 asterisks (**). (Table continued on next page.)

Botanical name and voucher [Kaburi SM & Kimeu JM]	Plant family	Local name (in Chuka)	Kariako occurrences	Mukungugu occurrences
**Acacia mearnsii* De Wild. [41]	Leguminosae	*Muthanduku*		Planted
Albizia gummifera (J.F. Gmel.) C.A. Sm. [34]	Leguminosae	*Mukorwe*	Natural, planted	
Argomuellera macrophylla Pax [no voucher]	Euphorbiaceae	*Muthatha*		Natural
***Bersama abyssinica* Fresen. [29]	Melianthaceae	*Mtong'omwe*		
Bridelia micrantha (Hochst.) Baill. [8]	Euphorbiaceae	*Mukwego*		Natural
Cajanus cajan (L.) Millsp. [6]	Leguminosae	*Mucugu*		Planted
**Calliandra calothyrsus* Meissn. [23]	Leguminosae	–		Planted
**Camellia sinensis* (L.) Kuntze [40]	Theaceae	*Mucani*	Planted	Planted
**Coffea arabica* L. [63]	Rubiaceae	*Muhua*	Planted	Planted
Cordia africana Lam. [7]	Boraginaceae	*Muringa*	Natural	Natural
Croton macrostachyus Delile [18]	Euphorbiaceae	*Muntuntu*	Natural	Natural
Croton megalocarpus Hutch. [4]	Euphorbiaceae	*Muciri*	Planted	Planted
Ehretia cymosa Thonn. [24]	Boraginaceae	*Murembu*	Natural	
Eriobotrya javanica (Thunb) Lindl. [16]	Rosaceae	*Munoa*		Planted, natural
**Eucalyptus grandis* Hill ex Maiden [31]	Myrtaceae	*Munyua mai*	Planted	Planted
**Eucalyptus saligna* Sm. [32]	Myrtaceae	*Munyua mai*	Planted	Planted
**Grevillea robusta* R. Br. [17]	Proteaceae	*Mikima*	Planted, natural	Planted, natural
***Landolphia buchananii* (Hallier f.) Stapf [46]	Apocynaceae	*Munakamwe*		
**Lantana camara* L. [10]	Verbenaceae	*Mucimoro*		Natural, planted
**Macadamia integrifolia* Maiden & Betche [15]	Proteaceae	*Mukandamia*		Planted
**Mangifera indica* L. [21]	Anacardiaceae	*Mwembe*	Planted	Planted
Markhamia lutea (Benth.) K. Schum. [44]	Bignoniaceae	*Muu*	Natural planted	Natural, planted
Myrianthus holstii Engl. [37]	Cecropiaceae	*Mucuca*	Natural	
**Persea americana* Mill. [14]	Lauraceae	*Mukondobia*	Planted	Planted
Prunus africana (Hook. f.) Kalkman [36]	Rosaceae	*Muiria*	Natural, planted	
Rauvolfia caffra Sond. [27]	Apocynaceae	*Muthura*	Natural	

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TABLE 1 Continued. (First part of Table 1 on previous page.)

Botanical name and voucher [Kaburi SM & Kimeu JM]	Plant family	Local name (in Chuka)	Kariako occurrences	Mukungugu occurrences
***Rothmannia urcelliformis* (Hiern) Robyns [43]	Rubiaceae	*Mukombokombo*		
Senna didymobotrya (Fresen.) Irwin & Barneby [62]	Leguminosae	*Mweno*	Natural	Natural
***Syzygium guineense* (Willd.) DC. [38]	Myrtaceae	*Muriru*		
Trimeria grandifolia (Hochst.) Warb. [45]	Flacourtiaceae	*Muvyevi*	Natural, planted	
Vernonia galamensis (Cass.) Less. [50]	Compositae	*Mucobo*	Natural	Natural
Vitex keniensis Turrill [3]	Verbenaceae	*Muburu*		Natural, planted

Opportunities for a sustainable fuelwood supply

At the market center, 36 residents (25 women, 11 men) from Kiang'ondu sublocation participated in the ranking of the fuelwood trees. They first described other material uses and the environmental services of the fuelwood species: All fuelwood tree species were reported to have multiple uses, and they described a total of 25 uses during the field exercise in addition to their use as fuelwood. Material uses included construction materials (timber, posts, roofing, and poles), tool handles, beehives and bee forage, utensils, edible parts (fruits, leaves, and seeds), beverages and flavoring, medicines, fodder, ropes, weaving materials, dye, repellent, and cosmetics. Environmental services included live fences, wind breaks, soil improvement, mulch, nitrogen fixation, river bank conservation, and some aesthetic/symbolic roles (ornamental, shade, boundary marking, ceremonial).

These other uses influenced people's enrichment efforts of fuelwood tree species either by conserving trees when naturally established or by planting them around their homes and farmlands. Participants described fruit trees (*Macadamia integrifolia*, *Mangifera indica*, and *Persea americana*), cash crops (*Coffea arabica* and *Camellia sinensis*), trees for construction materials (*Eucalyptus* species, *Grevillea robusta*, and *Cupressus lusitanica*), and fodder trees (*Argomuellera macrophylla* and *Grevillea robusta*) as fuel sources. For example, *Grevillea robusta* (a nonnative) had 11 other material uses, *Albizia gummifera* (a native) had 10 other uses, and *Cordia africana*, *Ehretia cymosa*, and *Vitex keniensis* (all native), and *Macadamia integrifolia* (nonnative) were each recorded with 9 other uses. They said that branches of shrubs, including *Bridelia micrantha*, *Calliandra calothyrsus*, and *Lantana camara*, are commonly fed to goats and later used as fuelwood materials. Likewise, *Argomuellera macrophylla* was a most common tree in Mukungugu, primarily used as fodder and thereafter utilized as a fuelwood resource. They also described the environmental services these trees provide, such as enhancing soil conservation when intercropped (*Calliandra calothyrsus*, *Psidium guajava*, *Camellia sinensis*, *Cordia Africana*, and *Ehretia cymosa*), trees planted as a live fence or to mark boundaries (*Vitex keniensis*, *Cupressus lusitanica*, and *Lantana camara*), and other services (shade, mulching, rainfall, air purification, ornament, soil fertility and conservation, and as a landmark).

The participants also described their attributes as a fuel (more heat and light, whitish ash, less smoke, rapid drying, and slow burning) and their in-field management as a fuelwood resource (propagation methods, seedling availability, germination, whether seedlings can be easily transplanted, and whether the tree sprouts easily after pruning). Direct planting of seeds on the sites (*Croton megalocarpus*) was reported to be less work than first raising seedlings in a seedbed and later transplanting them (eg *Cordia africana*, *Eucalyptus* species, and *Ehretia cymosa*). Residents managing big farms said that they utilized naturally established trees species like *Croton macrostachyus*, *Grevillea robusta*, and *Bridelia micrantha* because they do not require extra attention. *Argomuellera macrophylla* and *Grevillea robusta* are examples of trees that sprout quickly once pruned, thus ensuring a sustained supply of fuelwood materials.

By a show of hands, participants selected 10 most preferred fuelwood trees and then ranked these trees based on their other material uses and rendered services, and their attributes as a fuelwood resource (Table 2). Two were nonnative, and 8 were native species. *Eucalyptus grandis* (a nonnative) was ranked as the most valuable fuelwood (Table 2). The tree was reported with 1 negative fuelwood attribute, producing brownish ash after combustion, and 8 other uses/services. *Syzygium guineense*, an indigenous tree collected in the forest reserve, was recorded as the second most valuable fuelwood tree; the tree has 5 other recorded uses/services, produces more

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TABLE 2 The top 10 most preferred fuelwood plants ranked and described by participants in Kiang'ondu sublocation. Nonnative tree species are shown with 1 asterisk (*); the rest are natives.

Botanical names	Chuka names	Other material uses and environmental services	Fuelwood attributes and in-field management as a fuelwood resource
1. ***Eucalyptus grandis*** **Hill ex Maiden***	*Munyua mai*	Bee forage, timber, construction, medicine, windbreak, poles, tool handles, cosmetics	More heat and light, less smoke, dries quickly, burns slowly, seedlings available, germinates easily, wildings available, establishes naturally, sprouts quickly
2. ***Syzygium guineense*** **(Willd.) DC.**	*Muriru*	Bee forage, beehives, furniture, construction, medicine, charcoal	More heat and light, whitish ash, less smoke, burns slowly, seedlings available, germinates easily, wildings available
3. ***Prunus africana*** **(Hook. f.) Kalkman**	*Muiria*	Timber, furniture, construction, medicine, charcoal, shade, posts, tools, ceremonies	More heat and light, whitish ash, burns slowly, wildlings available
4. ***Grevillea robusta*** **R. Br.***	*Mukima*	Fodder, construction, mulch, windbreak, live fence, posts, ornamental, soil fertility and conservation, timber, furniture	Less smoke, dries quickly, seedlings available, germinates easily, wildings available, establishes naturally, sprouts quickly
5. ***Ehretia cymosa*** **Thonn.**	*Murembu/Mukui*	Bee forage, beehives, ornamental, soil conservation, timber, furniture, construction, medicine, boundary marking, charcoal, ceremonies	More heat and light, burns slowly, seedlings available, germinates easily, wildings available, establishes naturally
6. ***Bridelia micrantha*** **(Hochst.) Baill.**	*Mukwego*	Fodder, construction, poles, posts, charcoal	More heat, whitish ash, less smoke, burns slowly, wildlings available, establishes naturally, sprouts quickly
7. ***Cordia africana*** **Lam.**	*Muringa*	Bee forage, beehives, ornamental, soil conservation, timber, furniture, shade, construction, boundary marking, ceremonies	More heat, burns slowly, seedlings available, germinates easily, wildlings available, establishes naturally
8. ***Croton macrostachyus*** **Delile**	*Mutuntu*	Bee forage, fodder, soil conservation, shade, medicine	Dries quickly, seedlings available, germinates easily, wildlings available, establishes naturally
9. ***Croton megalocarpus*** **Hutch.**	*Muciri*	Bee forage, soil conservation, medicine, shade, wind break, live fence, charcoal	More heat, whitish ash, dries quickly, burns slowly, seedlings available, germinates easily, wildlings available, establishes naturally, sprouts quickly
10. ***Argomuellera macrophylla***	*Muthatha*	Fodder, bee forage, beehives, shade	More light, less smoke, dries quickly, seedlings available, sprouts quickly

heat and light, has whitish ash and less smoke, and the tree can be propagated by transplanting wild seedlings. *Argomuellera macrophylla* was ranked 10th on the list but still had 4 other recorded uses/services, and showed positive attributes as a fuelwood and potential for propagation (Table 2).

Transect walks across the landscape where people reside and household interviews gave participants an opportunity to show the ways in which their farmlands are managed for fuelwood resources. Ten Chuka residents (6 women and 4 men) were selected by their availability in Kariako, and 8 residents (3 women and 5 men) were selected in Mukungugu. Participants described and photographed some of the opportunities for sustaining fuelwood resources and showed how women, men, and children participated in different ways (Figure 3). Those residents who managed steep slopes on their farmland planted more trees, since the land cannot be used to grow other crops efficiently. They said that this was also a good practice to curb soil erosion during the rainy season. Men reported their greater involvement with fuelwood resources as the distance to the sites increased and infrastructure improved (Figure 3). They used diverse modes of transport such as wheelbarrows, bicycles, and

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cars to obtain fuelwood materials from more distant locations. In both localities, women reported involvement in a greater number of fuelwood-related activities, including preparing fire, warming water, cooking food, and walking to collect fuelwood locally. Children also collect fuelwood and helped with the planting and tendering of fuelwood trees planted in their homes and farmlands, especially in the evening, when they got back home after school.

Discussion

Fuelwood is a vital energy resource in tropical montane environments, which often support dense, rural, isolated, and low-income populations in regions of high biodiversity. For example, fuelwood provides >70% of household energy consumption in the Himalayas (Ali and Benjaminsen 2004) and is estimated at over 90% for montane forests in Kenya (Gathaara 1999). The purpose of this research was to gain a better understanding of fuelwood extraction and, more importantly, enrichment practices that contribute to the energy needs of local communities near Mount Kenya Forest Reserve. Chuka community residents in Kiang'ondu sublocation were asked to jointly investigate their local activities and perceptions on the use and conservation of fuelwood resources, validating their role in local assessment and analysis. All participants relied on fuelwood as their only energy source. From our study findings, we highlight the way in which diverse fuelwood resources can be supported through extraction and enrichment practices and development opportunities for fuelwood sustainability in mountain environments.

Diversity in the management of fuelwood resources

Similar to other ethnobotanical surveys on East African mountains (eg Lado [2004] for Mount Elgon, Kenya; Hemp [2006] for Mount Kilimanjaro, Tanzania; Medley et al [2007] for Mount Kasigau, Kenya), participants in Kiang'ondu sublocation named a high diversity of fuelwood trees and knew these trees by their fuelwood attributes and other material and nonmaterial uses. These "human-modified systems" not only maintain a high diversity of trees but also represent many material and nonmaterial reasons for the presence of these trees (Cunningham 2001).

Both native and nonnative trees contribute greatly to the diversity of fuelwood resources in the Kiang'ondu sublocation. For communities living close to the forest reserve, like Kariako, there is a higher use of native trees that occur in the protected reserve or are naturally established in their farmland. These trees may be vulnerable to overuse, as noted in a study of biodiversity at Ramogi Hill in Kenya (Bagine 1998), but their local value as a resource can also encourage community conservation efforts (Cunningham 2001; Hemp 2006). Communities living further from indigenous forests, like Mukungugu, use and plant more fast-growing nonnative trees as a way of complementing resource sustainability (Warner 2000). This study shows differences in the selection and management of fuelwood plants between these 2 communities, demonstrating the importance of local geography when interpreting resource conditions (Arnold et al 2005).

Chuka communities enrich species in their farmlands by conserving and planting trees; both are important practices in montane settings (Lengkeek et al [2005] for Mount Meru; Hemp [2006] at Mount Kilimanjaro) and offset forest degradation for energy needs on Mount Kenya (Bussmann 1996). For example, nonnative fruit trees, including *Macadamia integrifolia*, *Mangifera indica*, and *Persea Americana*, are widely distributed in the Kiang'ondu sublocation because they are fast maturing and provide cash incomes to households; they also are viable and valued sources of fuelwood. Tree species composition varies greatly within this narrow 5 km montane forest buffer zone, mostly because of individual choices on which species to extract, which species to conserve, and which species to plant.

Development opportunities for a sustainable fuelwood supply

Forest reserves and people's farmlands are integrated places for obtaining and planting a variety of fuelwood trees. Issues of where, when, how, who, and why become important when interpreting opportunities for energy security. Gender roles related to fuelwood extraction and enrichment in the Kiang'ondu sublocation are influenced by many factors, including resource distribution patterns, infrastructure, plot size, and other work activities. Like communities in the Andes, "everyone is involved in everything" (Paulson 2005: 180). The findings from this study complicate generalities about gendered roles and support the need for gender-sensitive analyses on fuelwood management in relation to human livelihoods (Rocheleau et al 1996). Maathai (2006:136) refers to community members as "foresters without diplomas" and emphasizes people's adaptive resource behaviors in response to the conditions provided to them. Engaging local community members during the research process shows the ways in which local knowledge and geographic analyses complement learning about the opportunities viewed critical in any resource management plan (Slocum et al 1998).

The community members who participated in the study did not report a shortage of fuelwood; from their perspective, they are not fuelwood limited. Kariako residents, living near the forest reserve, report that they have easy access to forest resources and have the option of extracting or enriching their fuelwood supply. Communities living further from the forest reserve can propagate fast-growing trees, or they can nurture naturally established trees in their farmlands. Maathai (2006) describes similar experiences with local community groups

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FIGURE 3 Photos that show some of the opportunities for a sustainable supply of fuelwood resources in Kiang'ondu sublocation described by men and women respondents. (Photos by the authors)

A)

Mukungugu residents describe a close relationship between other material uses (eg fodder) and fuelwood. Fodder from some fuelwood species such as *Lantana camara* and *Argomuellera macrophylla* were used as fuelwood after being fed to livestock. The stems seen in the foreground are from an *Argomuellera macrophylla* tree that was growing in the farmlands.



B)

A farmer from Kariako locality shows a young naturally established *Grevillea robusta* tree that was left to continue growing. Beside the seedling is the stump of an old tree that was used as fuelwood. Natural establishment of fuelwood trees from stumps was reported as a common way in which fuelwood trees propagate in both localities.



C)

The woman in this photo, standing in her farmland, points to the direction of the forest reserve. Residents in Kariako locality who live near the forest reserve reported that they rely on it for their fuelwood needs. Nevertheless, they still conserve trees in their homes and farmlands mainly for other materials used by them.



D)

This man is transporting fuelwood from the forest reserve on a bicycle. A good road network encouraged men to participate in fuelwood acquisition (and sometimes sales). Men and boys use transportation modes such as wheelbarrows, bicycles, and cars.



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working with the Green Belt Movement in Kenya and employs an understanding of these diverse approaches toward local reforestation initiatives. These findings, while supporting current debates that question the impacts of fuelwood extraction on forest condition (Ali and Benjaminsen [2004] on the "theory of Himalayan environmental degradation"), also emphasize the need for comparative studies to better understand and ensure that local perceptions about fuelwood conditions match environmental assessments at regional scales (Arnold et al 2005).

Policy recommendations

Our study further substantiates the need to shift local respondents from passive participants to collaborators in the research process and the conservation of energy resources (Colfer 2005). Community residents can identify a diversity of fuelwood resources and describe their relative value in relation to fuelwood attributes and in-field management practices. They demonstrate the importance of local understanding about both extraction and enrichment practices in ways that can directly boost local conservation activities. All members of the community rely on fuelwood for their energy needs, are involved in the management of fuelwood resources, and are sensitive to its continued sustainable supply. Together, they can contribute to development opportunities for fuelwood conservation across the complex and integrated agro-forested landscapes of montane environments.

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